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EXPLOSIVES RESEARCH LABORATORY

SENSITIVITY CHARACTERISTICS OF LIQUID EXPLOSIVE SYSTEMS

Progress Report No. 5
January 1, 1963 to March 31, 1963

BUREAU OF MINES, PITTSBURGH, PA.

UNITED STATES
DEPARTMENT OF
THE INTERIOR

SENSITIVITY CHARACTERISTICS OF LIQUID EXPLOSIVE SYSTEMS

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Prepared for:

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INTRODUCTION

This is the fifth report in a series describing the experimental results obtained in a research program established to evaluate the safety hazards associated with high-energy liquid explosive systems in cooperation with the Bureau of Naval Weapons, U. S. Department of the Navy.

Studies were made of shock sensitivity of explosive systems. These include investigations of the effect of type of container and confinement on the results observed in shock sensitivity measurements.

EXPERIMENTAL RESULTS AND DISCUSSION

The card gap sensitivity is a measure of the relative ease of initiation of high velocity detonation by an intense shock wave. Experiences with the gap test have shown that this experimental technique does not enable us to completely evaluate the sensitivity of a material. It has been found (as described in a previous report[1/]) that a modification of this procedure, which we call the "combination gap-rate test," is much more informative, inasmuch as gap values and detonation rates are measured simultaneously.

The gap-rate procedure is being used to observe the effect of the type of container used upon the test results.

1/ Mason, C. M., J. Ribovich. Sensitivity Characteristics of Liquid Explosive Systems. Bureau of Mines Progress Report No. 3, July 1, 1962 to September 30, 1962 (Confidential).

In summarizing the results obtained with different containers one observed physical difference between the containers was the sound velocity. Low velocity reactions were observed in containers of high sound velocity, glass, iron and aluminum (5000 - 6000 m/sec) but not in containers of low sound velocity, lead and Lucite (1200 and 2500 m/sec, respectively). Copper was observed to be intermediate in sound velocity (3500 m/sec) and studies were made in copper containers.

Studies were made at 25°C with Cavea-B-110 and with a 50-50 mixture of nitroglycerin and ethyleneglycol dinitrate (NG-EGDN) in approximately 1-inch id x 16-inch long containers of varying wall thicknesses. For Cavea-B in copper containers, gap versus wall thickness relationships were determined for both the high velocity detonation (approximately 7500 m/sec) and the low velocity reaction (approximately 2000 m/sec or less) in wall thicknesses ranging from 0.020-inch to 0.126-inch. With card gaps of approximately 0.9 inch and 0.1 inch, high velocity detonations were observed for Cavea-B in 0.020-inch and 0.126-inch wall copper containers, respectively. The card gap values above which the low velocity reaction is obtained and below which a high velocity detonation results, decrease with an increase in wall thickness (Figure 1).

With card gaps of approximately 3 and 4 inches, low velocity reactions were observed with Cavea-B in 0.020-inch and 0.126-inch wall copper containers, respectively. The results of the trials are given in Table 1. The card gap values above which incomplete reaction or no initiation is obtained and below which low velocity reaction results, increase with an increase in wall thickness (Figure 1).

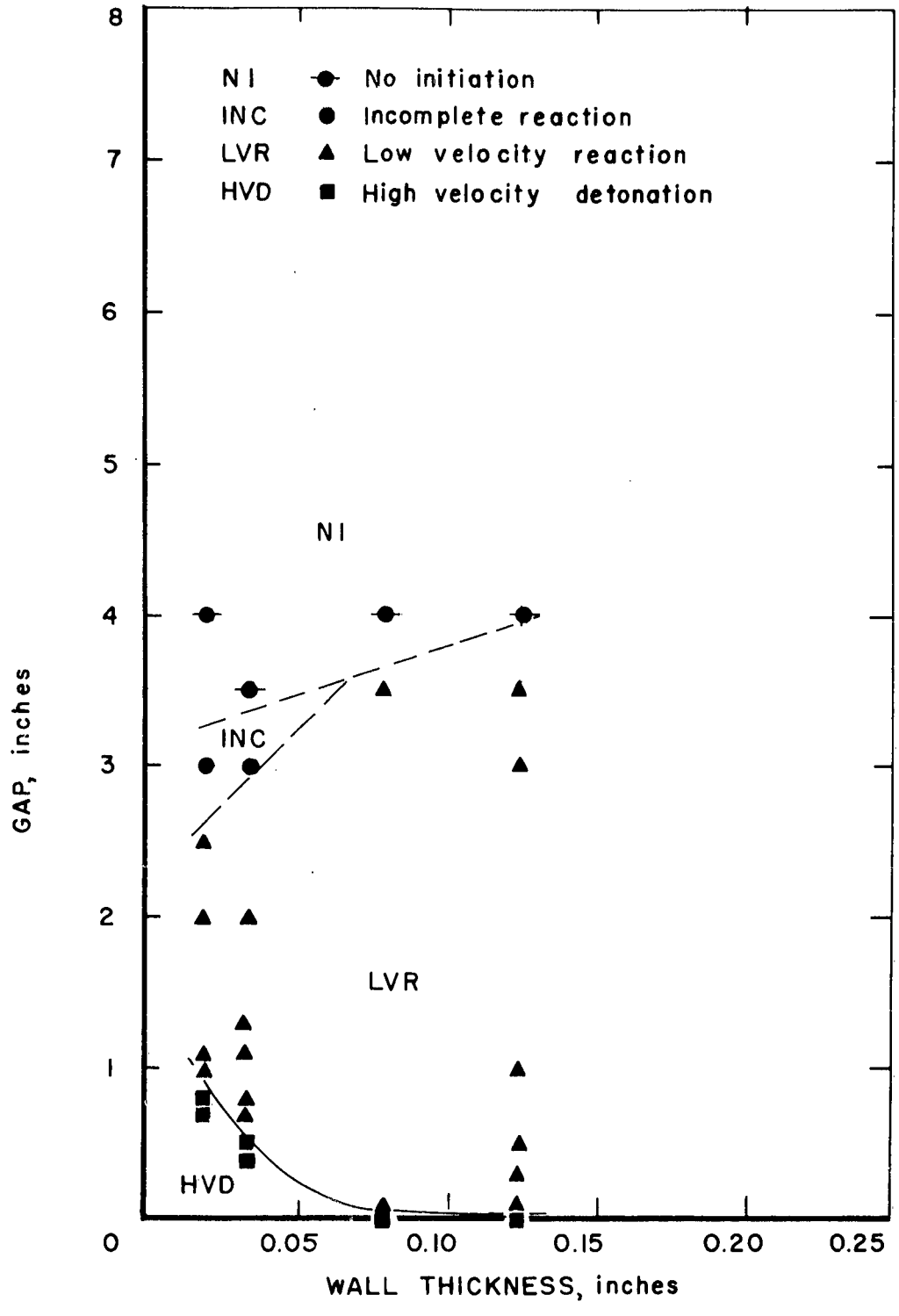

Figure 1. - Gap sensitivity of Cavea-B-110 in 1 x 16-inch copper containers at 25°C.

Table 1. - Shock sensitivity data at 25°C
Sample: Cavea-B-110
Container: Copper, approx. 1-inch id x 16 inches long

Card Gap, inches	Results[1/] Container: id x wall, inches			
	1.055 x 0.020	1.055 x 0.035	1.063 x 0.080	1.063 x 0.126
zero			7500-7580	7280-7500
0.1			1840-2230	2510-2430
.3				2290-2400
.4		7430-7580		
.5		7280-7430		2020-1890
.7	7430-7650	2380-2480		
.8	7500-7500	2350-2030		
1.0	2370-2290			2180-1770
1.1	2400-2480	2220-2360		
1.3		2250-2370		
2.0	2090-2480	1640-2340		
2.5	2370-2130			
3.0	Inc. 5"	Inc. 5"		1010-1090
3.5		NI	810 -	1370-150
4.0	NI		NI	NI

1/ Rates measured using T-2 targets at 8-inch and 11-inch, and 11-3/8-inch and 14-3/8-inch positions (7-1/2 cm apart) on the same charge.

Inc. - incomplete reaction - value indicates the distance at which decay occurred in the container.

NI - no initiation as indicated by little damage to container.

For 50-50 NG-EGDN the gap versus wall thickness relationship for high velocity detonation (approximately 7500 m/sec) was found to have a negative slope in both steel and aluminum containers (Figures 2 and 3). This behavior is analogous to results obtained with Cavea-B in steel, aluminum, and copper.[2/] For example, with card gaps of approximately 1.5 inches and 0.4 inch, high velocity detonations were observed for NG-EGDN in 0.020-inch and 0.133-inch wall steel containers, respectively. Low velocity reactions (approximately 2000 m/sec or less) were obtained with NG-EGDN in 0.020, 0.035, and 0.133-inch wall thicknesses at gaps up to and including 12 inches. In a single trial in Shelby tubing (1.63-inch id x 0.64-inch wall) with a 2-inch gap, a low velocity reaction (2110-1510 m/sec) was observed with NG-EGDN. The results of the trials are summarized in Table 2. For NG-EGDN in aluminum containers, high velocity detonations were observed with card gaps of approximately 1.8 inches and 1.2 inches in 0.020-inch and 0.133-inch wall thicknesses, respectively. Low velocity reactions were observed with aluminum containers of 0.0015, 0.020, 0.035, and 0.133-inch wall thickness at gaps up to 12 inches. No attempt was made to extend the studies with NG-EGDN to gaps greater than 12 inches. The results of the trials are given in Table 3 and Figure 3.

Studies of this type are being extended to the hydrogen peroxide-glycerin system and to nitromethane.

2/ Mason, C. M., J. Ribovich, and M. L. Weiss. Sensitivity Characteristics of Liquid Explosive Systems. Bureau of Mines Progress Report No. 4, October 1, 1962 to December 31, 1962 (Confidential).

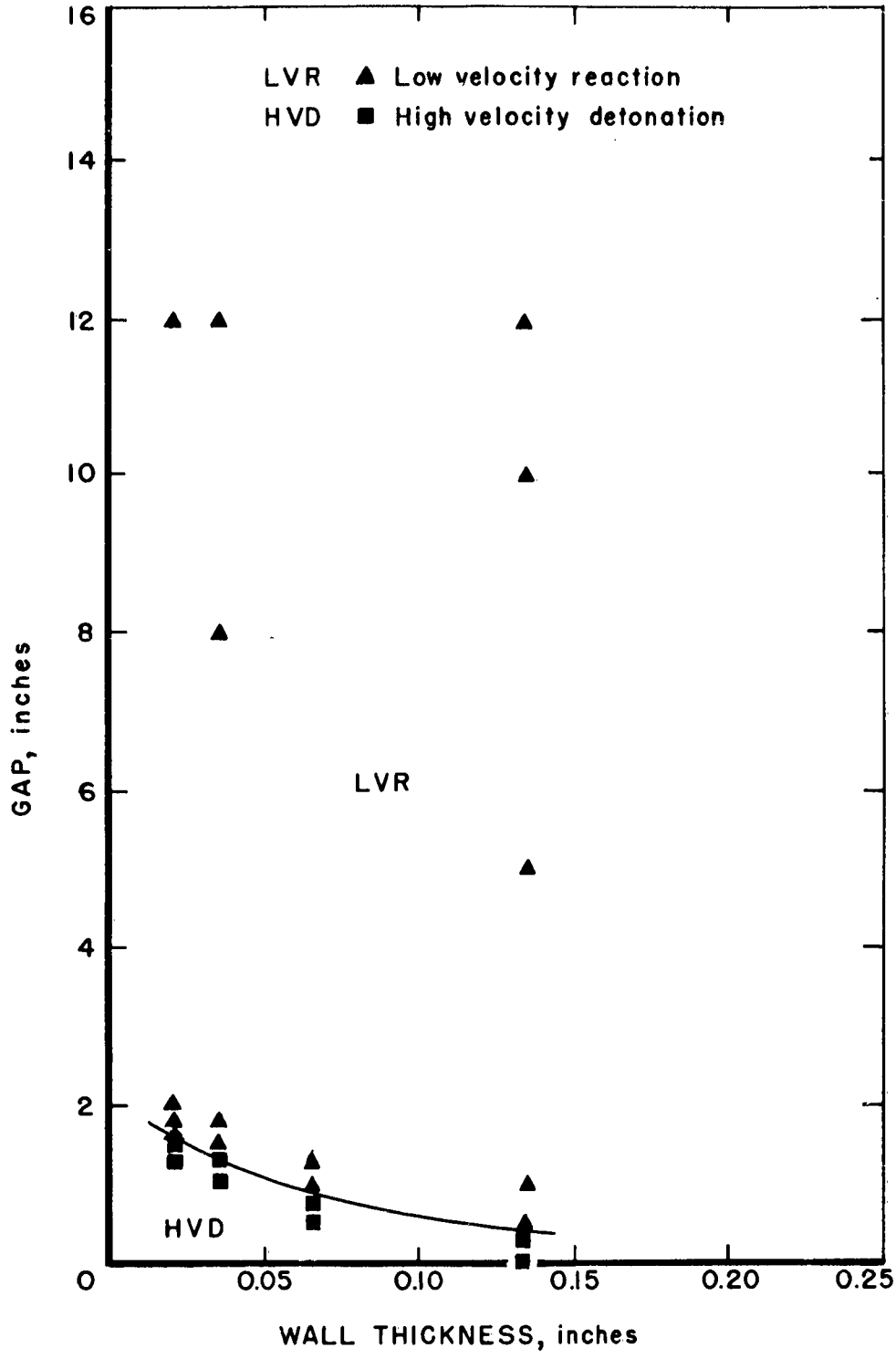

Figure 2. - Gap sensitivity of 50-50 NG-EGDN in 1 x 16-inch steel containers at 25°C.

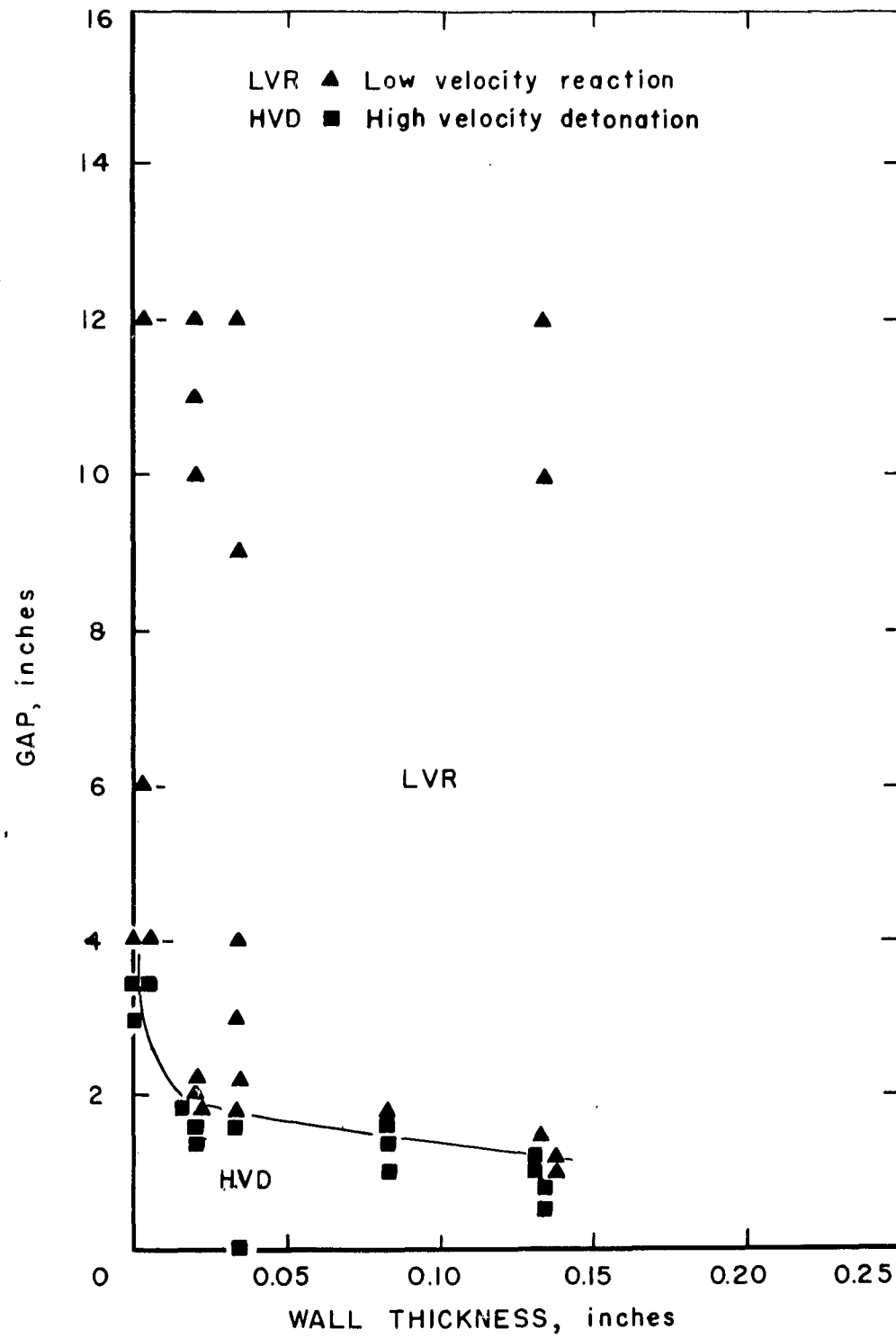

Figure 3. - Gap sensitivity of 50-50 NG-EGDN in 1 x 16-inch aluminum containers at 25°C.

Table 2. - Shock sensitivity data at 25°C
Sample: 50-50 NG-EGDN
Container: Steel, approx. 1-inch id x 16 inches long

Card Gap, inches	Results[1/] Container: id x wall, inches			
	1.055 x 0.020	1.055 x 0.035	1.057 x 0.065	1.05 x 0.133
zero				7580* 7520*
0.3				7330*
.4				7460*
.5			7430-7500	2010*
.7			7500 —	
1.0		7580-7500	1600 —	2030* 2040* 2010*
1.3	— 7430	7430-7500	1510-1690	
1.5	— 7500 1360-1380	1420-1840		
1.8	1400 —	— 1450		
2.0	1490-1650			
5.0				2040*
8.0		500-1020		
10.0				2000*
12.0	1450-450	550-1880		2030-2090

1/ Rates measured using T-2 targets at 8-inch and 11-inch, and 11-3/8-inch and 14-3/8-inch positions (7-1/2 cm apart) except those marked (*) using T-1 targets at 6-inch and 14-inch positions (20 cm apart). Where two rates are given both were measured on the same charge.

Table 3. - Shock sensitivity data at 25°C
Sample: 50-50 NG-EGDN
Container: Aluminum, approx. 1-inch id x 16 inches long

Card gap, inches	Results[1/] Container: id x wall, inches				
	1.05 x 0.0015	1.055 x 0.020	1.055 x 0.035	1.084 x 0.083	1.05 x 0.133
zero			7550*		
0.5					7430-7500
.8					7280-7580
1.0				7280-7580	7500-7650 1990-2040
1.2					7500-7580 1920-1970
1.4		7350-7350		7430-7650	
1.5					1900-1980
1.6		7430-7500	HVD	7500-7350	
1.8		7350-7580 2090-1500	LVR	1890-1930	
2.0		1540 --			
2.2		1510-1450	1250*		
3.0	HVD		1290*		
3.5	HVD HVD				
4.0	LVR LVR		1270*		
6.0	LVR				
9.0			1350*		
10.0		1230 --			2020-1980
11.0		1340-1500			
12.0	LVR	1280 --	LVR		1870-2020

1/ Rates measured using T-2 targets at 8-inch and 11-inch, and 11-3/8-inch and 14-3/8-inch positions (7-1/2 cm apart) except those marked (*) using T-1 targets at 6-inch and 14-inch positions (20 cm apart). Where two rates are given both were measured on the same charge.

HVD - high velocity detonation as indicated by a clean hole in the 1/4-inch thick steel witness plate.

LVR - low velocity reaction as indicated by total fragmentation of container and a dome in the 1/4-inch thick steel witness plate.

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